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Vranish

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[54] **THREE-DIMENSIONAL ROLLER LOCKING SPRAGS**

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[73] Assignee: **The United States of America as represented by the Administrator of National Aeronautics and Space Administration**, Washington, D.C.

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[22] Filed: **Jul. 27, 1994**

[51] **Int. Cl.**[6] **F16D 41/07**

[52] **U.S. Cl.** **188/6**; 192/45.1

[58] **Field of Search** .... 188/6, 82.2, 82.3, 188/82.84, 82.8; 192/41 A, 45.1

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Assistant Examiner—Chris Schwartz
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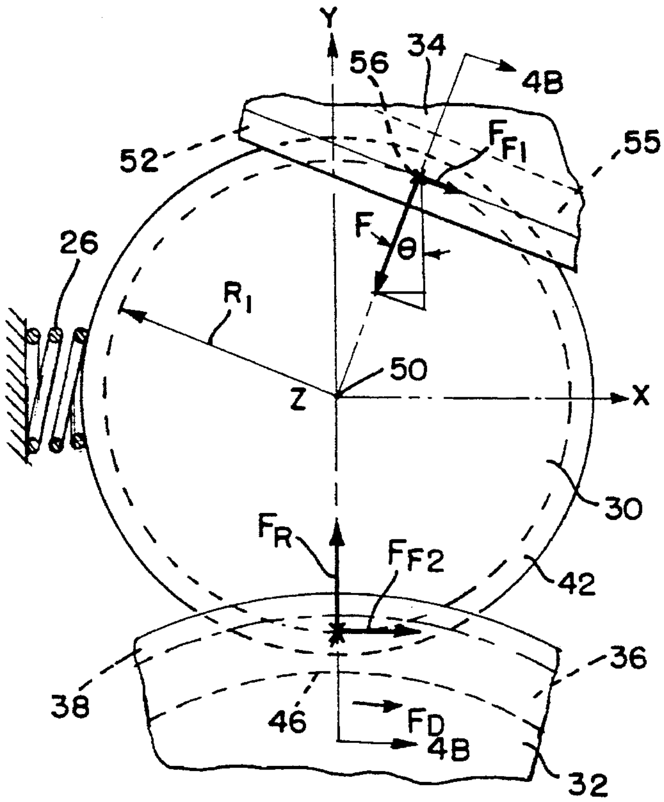
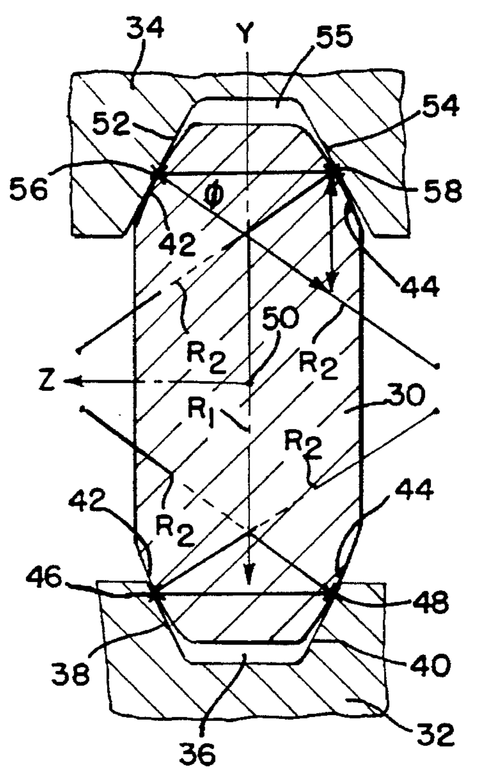
[57] **ABSTRACT**

A torque coupling sprag system which provides contact between the sides of at least one groove and at least two contact surfaces angled with respect to the central axial direction of at least one rotatable 3-D sprag member located between a drive member and a reaction member. The surface contacts between the members include various combinations of surface segments arranged in a predetermined manner to define a desired configuration. The contact radius of the 3-D sprag member is significantly larger than its rolling radius; however, radii can be varied in size and shape independently of each other, particularly the contact radius.

27 Claims, 3 Drawing Sheets





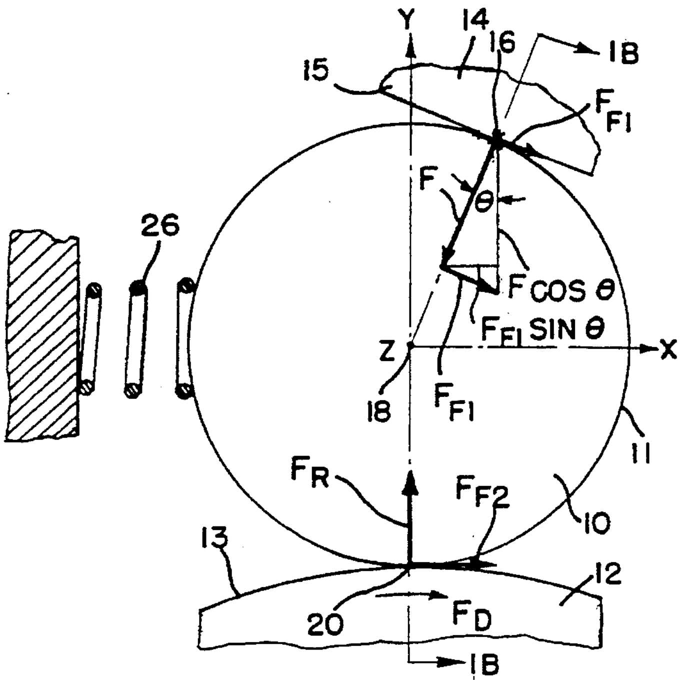


FIG. 1A
PRIOR ART

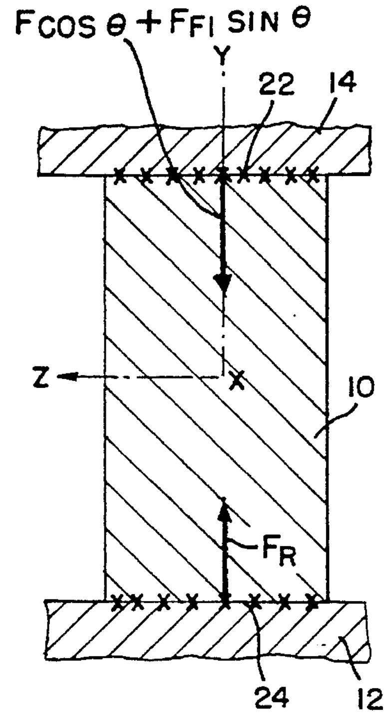


FIG. 1B
PRIOR ART

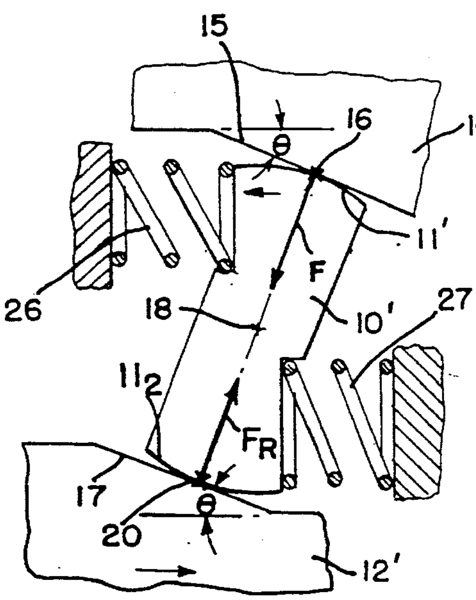


FIG. 2
PRIOR ART

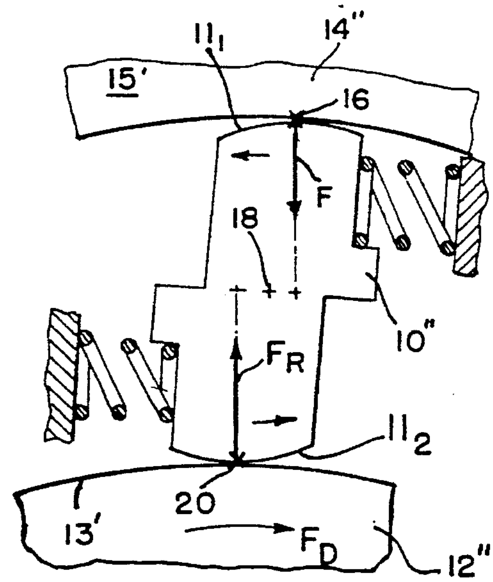


FIG. 3
PRIOR ART

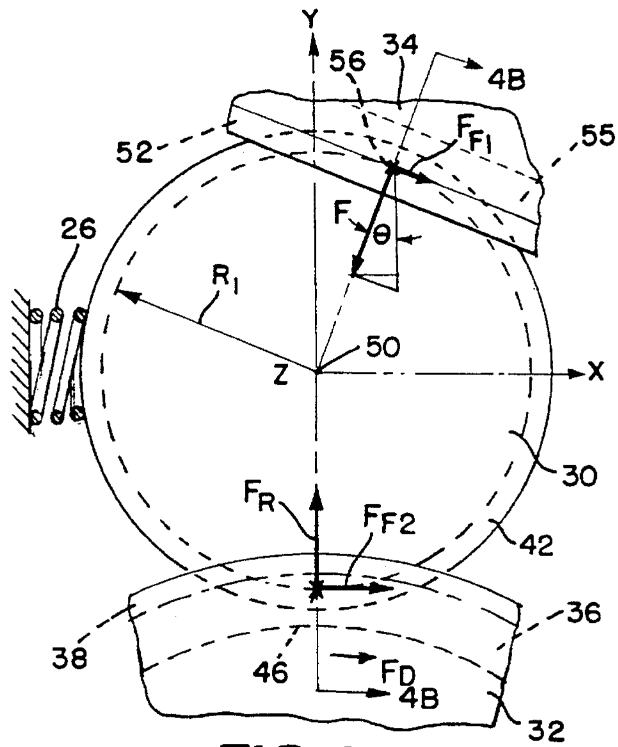


FIG. 4A

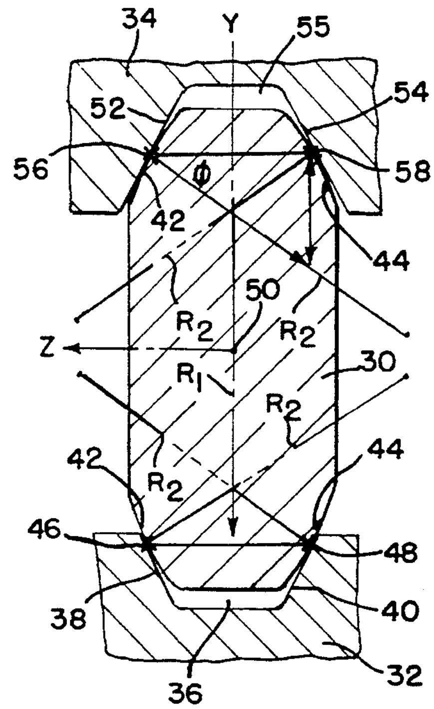


FIG. 4B

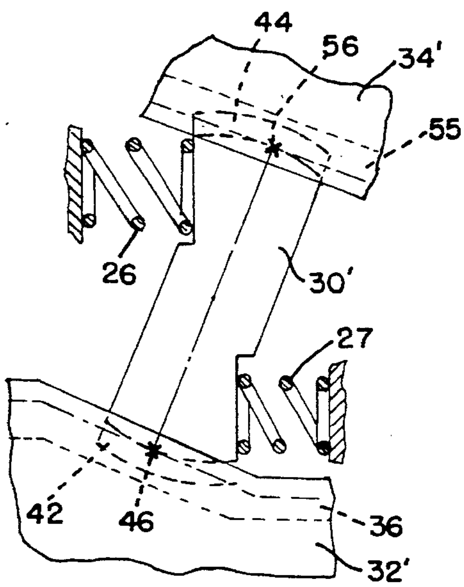


FIG. 5

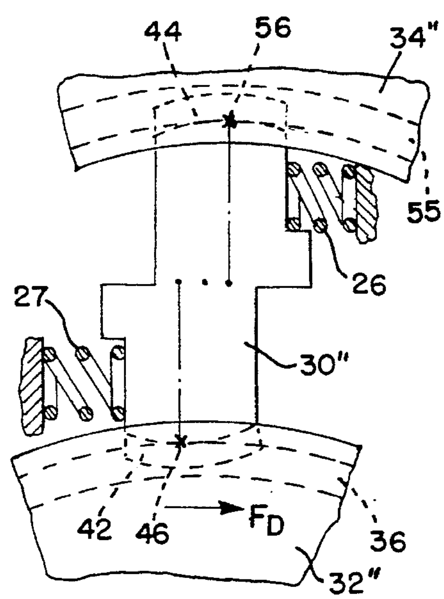


FIG. 6

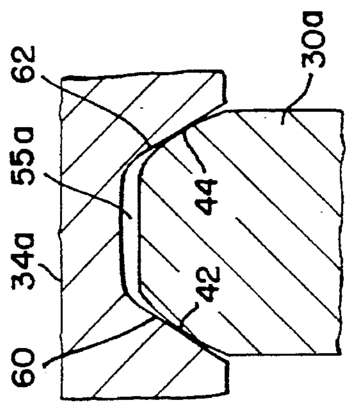


FIG. 7A

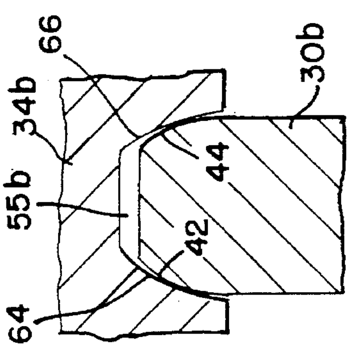


FIG. 7B

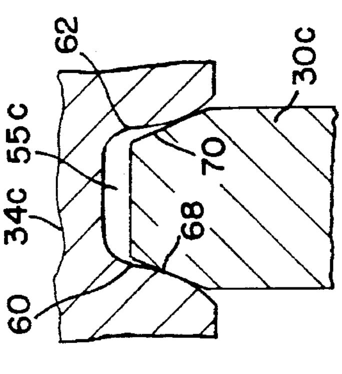


FIG. 7C

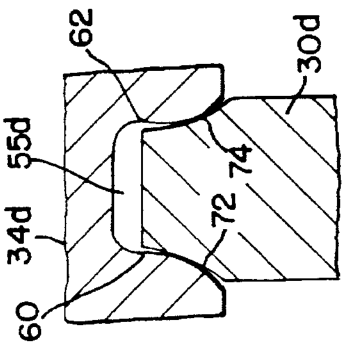


FIG. 7D

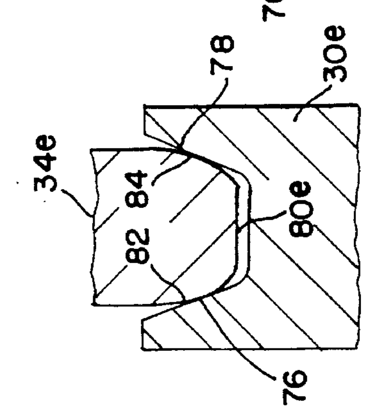


FIG. 8A

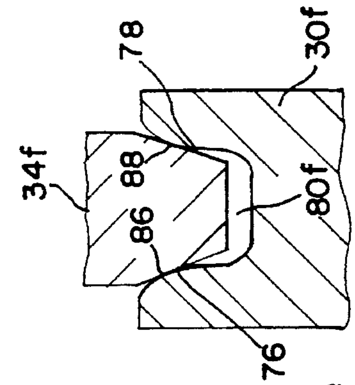


FIG. 8B

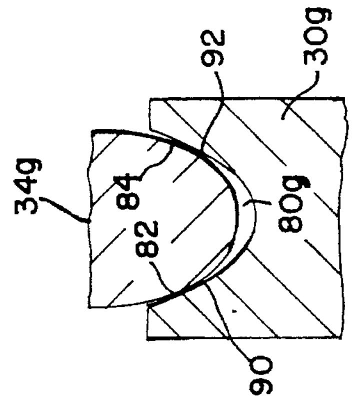


FIG. 8C

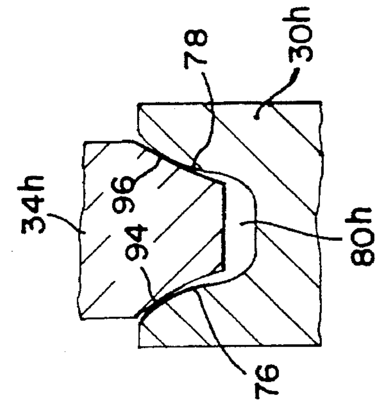


FIG. 8D

THREE-DIMENSIONAL ROLLER LOCKING SPRAGS

ORIGIN OF THE INVENTION

This invention was made by an employee of the United States Government and may be used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

1. Field of the Invention

This invention relates generally to mechanical brake and clutch devices and more particularly to roller type locking sprag devices which operate to couple torque between a drive member and a reaction or fixture member.

2. Description of the Prior Art

Locking techniques using ball or roller members are well known and have been used extensively in various types of clutch mechanisms. In such apparatus, the motion of one member, referred to as a driver member, forces a ball or roller to wedge against an inclined surface of another member, referred to as a reaction or fixture member. A sprag, to which the present invention is directed, comprises a roller having a line contact bearing surface as opposed to a point contact surface of a ball and is used where relatively large loads and contact stresses are encountered. Sprags typically have mutually opposing or slightly offset two dimensional cylindrical contact surfaces located between a drive surfaces located between a drive member and a reaction member and having a body which comprises a portion of a roller and which are spring biased against the contact surface of the drive member and the reaction member.

Known prior art type sprags typically have relatively small cam angles or inclines, normally on the order of 6. Thus, they must have relatively large contact stresses in order no generate sufficient holding torque when transferring torque from the drive member to the reaction member. The combination of these large contact stresses and the small cam angles requires large radial forces which in turn, force the walls of the device to be thick and long. It also forces the sprags to be relatively long. This results in sprag devices utilized, for example, in over-running clutches, to be heavier and bulkier than necessary. Also, the machining tolerances on the cams must be very close because if a 6° cam is machined too closely, the roller tries to move over center and jams to the point where it will not come out and excessive forces in clutch damage may result. If, on the other hand, the cam angle of the incline surface is too large, such as being greater than 6°, the clutch will slip. For example, in space where the coefficient of friction can vary by as much as 25%, a 6° cam can be vulnerable in its utilization.

SUMMARY

It is an object of the present invention, therefore, to provide an improvement in roller type locking brakes and clutches.

It is another object of the invention to provide an improvement in roller-type locking sprag systems.

It is a further object of the invention to provide a sprag system which is more effective and reliable in its ability to provide a lock-up between a drive member and a reaction member.

It is yet another object of the invention to provide a sprag member which is relatively shorter in axial length than conventional sprags without any sacrifice in performance.

It is yet a further object of the invention to overcome the requirement of relatively thick and long sprag members resulting from large contact stress and small cam angles.

It is still a further object of the invention to provide a three-dimensional sprag system having at least one sprag member which is confined to a groove so that it cannot migrate axially between a drive member and a reaction member.

Briefly, the foregoing objects and advantages are realized by a torque coupling sprag system which is three-dimensional in nature where the change is effected from a cylindrical type sprag contact to a contact between the sides of at least one groove and at least two contact surfaces angled with respect to the central axial direction of at least one sprag member located between a drive member and a reaction member. The sprag member is rotatable between the reaction member and the drive member, which have an angle therebetween defined by a straight line passing through a central rotatable axis and a first pair of contact surfaces on the drive member and a straight line passing through the central axis and a second pair of contact surfaces on the reaction member. The surface contacts between the members include various combinations of diametrically opposed flat and curved contact surface segments arranged in a predetermined manner to define a desired configuration.

BRIEF DESCRIPTION OF THE DRAWINGS

The following detailed description of the invention will be more readily understood when considered together with the accompanying drawings wherein:

FIG. **1A** is a side elevational view of a typical known prior art sprag device;

FIG. **1B** is a cross sectional view of the embodiment shown in FIG. **1A** taken along the lines **1B**—**1B** thereof;

FIGS. **2** and **3** comprise side elevational views illustrative of other prior art sprag devices;

FIG. **4A** is a side elevational view of a first embodiment of the subject invention;

FIG. **4B** is a cross sectional view illustrative of the embodiment shown in FIG. **4A** taken along the lines **4B**—**4B** thereof;

FIGS. **5** and **6** are side elevational views of second and third embodiments of the subject invention;

FIGS. **7A**—**7D** are partial cross-sectional views illustrative of a first set of modified versions of the embodiment shown in FIGS. **4A** and **4B** including male type sprags and female type fixtures;

FIGS. **8A**—**8D** are cross-sectional views of a second set of modified versions of the embodiment shown in FIGS. **4A** and **4B** including female type sprags and male type fixtures.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the figures wherein like reference numerals refer to like parts throughout, reference will first be made to FIGS. **1A** and **1B** which are illustrative of a conventional two-dimensional (2-D) roller locking sprag arrangement comprising a cylindrical type sprag member **10** located between a rotary type drive member **12** and a rotary type reaction member **14**, which may also be referred to as a fixture. The reaction member or fixture **14** has an inclined roller contact or cam surface **15** which is inclined at an angle θ with respect to a Y axis of an orthogonal X, Y, Z axis system passing through the center of the sprag member **10** and which makes contact therewith at contact point **16**. The sprag member **10** also makes contact with the driver member **12** at contact point **20**.

As depicted in FIG. **1**B, the sprag member **10** has a thickness dimension along the Z axis which results in contact with the driver and reaction members **12** and **14** along the lines **22** and **24**. The contact point **16** shown in FIG. **1**A lies along the line **22** and the contact point **20** on the line **24**. Further, the sprag member **10** is spring biased against the drive member **12** and the reaction member **14** by a preload spring member consisting of a compression spring **26** causing tangential frictional forces to build up along the contact surface lines **22** and **24** between the surfaces **11**, **13** and **15**.

in operation, torque is coupled from the drive member **12** to the reaction member **14** when, as shown in FIG. **1**A, the drive member **12** rotates in a clockwise direction. This causes the sprag member **10** to rotate around the Z axis in a counterclockwise direction and roll up the inclined surface **15** of the reaction member **14**. The sprag member **10** will wedge itself between the reaction member **14** and the drive member **12** with frictional forces F_{F1} and F_{F2} developing, at which time lock-up occurs and the torque provided by the drive member **12** will be transferred or coupled to the reaction member **14** which will then also rotate in a clockwise direction along with the drive member **12**.

At lock-up, in addition to the frictional forces F_{F1} and F_{F2}, there exists a force F which is applied by the reaction member **14** to the sprag member **10** directed toward the Z axis and normal to the inclined surface **15** as well as a reaction force directed from the driver member **10** directed along the Y axis. Further at such time the summation of the forces along the X axis and Y axis and the moments about the Z axis are all equal to zero.

Referring to FIGS. **1**A and **1**B, these relationships can be expressed as follows. For the summation of forces along the X axis:

$$\Sigma F_x = 0 \tag{1}$$

and it can be shown that

$$F \sin \theta = F_{F1} \cos \phi + F_{F2} \tag{2}$$

With respect to the forces along the Y axis,

$$\Sigma F_y = 0, \tag{3}$$

and

$$F \cos \theta + F_{F1} \sin \theta = F_R \tag{4}$$

With respect to the moments about the Z axis, they are also equal to zero, such that,

$$\Sigma M_Z = 0, \tag{5}$$

therefore

$$F_{F1} = F_{F2} \tag{6}$$

Typically sprag clutches are designed such that F_{F2} slips first during unlocking of the elements **10**, **12** and **14**, then

$$F_{F2} = F_R \mu s \tag{7}$$

where μs is a coefficient of friction between the sprag member **10** and the driver member **12**.

Using equations (2), (6) and (7), it can be further shown that

$$F \sin \theta = F_{F2} (1+\cos \theta) = F_R\ \mu s\ (1+\cos \theta) \tag{8}$$

Accordingly,

$$F \sin \theta / F_R\ (1+\cos \theta) \leqq \mu s \tag{9}$$

Depending upon the value of μs which is a limit indicative as to when slippage occurs, the maximum angle of θ is governed by the relationship as expressed in equation (9) and for 2-D sprags (FIGS. **1**A and **1**B). The sprags are normally operated in a lubricant. Accordingly, μs is small resulting in a small **8**, typically on the order of 6°.

Prior to considering the embodiments of the subject invention, reference will first be made to FIGS. **2** and **3** which are illustrative of 2-D sprag systems which utilize only a partial section of a cylindrical roller. As shown in FIG. **2**, the sprag member **10**' comprises a body member having a pair of curved surfaces $\mathbf{11}_1$ and $\mathbf{11}_2$ which respectively contact the inclined surfaces **15** and **17** of the reaction member **14**' and the drive member **12**' at contact points **16** and **20**, respectively. In this embodiment, both inclined surfaces **15** and **17** have equal cam angles (8). It should be noted, however, that these cam angles do not have to be equal. They are shown as such for the sake of simplicity and thus are not meant to be limited thereto.

Now instead of having a single preload bias spring **26** as shown in FIG. **1**A, the sprag member **10**' of FIG. **2** includes a second preload spring **27** so that a spring bias is applied above and below the center or pivot point **18**. The configuration of FIG. **2** is one in where a linear motion of the sprag member **12**' is transferred or coupled to the reaction member **14**' This is due to the fact that when the sprag member **12**' moves to the right as shown, the surface **112** of the sprag member **10**' rolls up the incline surface **17** and in doing so, the upper curved surface **111** rolls up the incline surface **15** of the reaction member **14**', causing it to lock-up in a conventional manner. A movement of the drive member **12**' in the opposite direction releases the coupling between the drive member **12**' and the reaction member **14**' as the sprag member **10**'.

Referring now briefly to FIG. **3**, it includes a sprag member **10**" which is structurally similar to that shown in FIG. **2**, with the exception that rather than the contact points **16** and **20** being aligned with the pivot **18**, in the configuration shown in FIG. **2**, offset radii are contemplated and as a result, the contact points **16** and **20** are mutually offset from one another on either side of the pivot **18**. Also, the contact surfaces between the sprag member **10**" and the drive member **12**" and the reaction member **14**" are curved surfaces as shown by reference numerals **13**' and **15**'.

Directing attention now to the preferred embodiments of the subject invention, FIGS. **4**A and **4**B are illustrative of a torque coupling system where the driver member **32** and the incline, i.e. the reaction member **34** are both grooved and the sprag member **30** rolls along a path common to both grooves, with two side surfaces of the sprag member making contact with diametrically opposing sides of the grooves.

As illustrated in FIG. **4**B, the drive member **32** includes a groove **36** having a pair of mutually diverging side wall surfaces **38** and **40** which contact a pair of curved peripheral side surfaces **42** and **44** of the sprag member **30**. The pair of side wall surfaces **42** and **44** of the sprag member **30** contact the side wall surfaces **38** and **40** of the driver member **32** in the diametrically opposing regions **46** and **48** and which are located at a radius R_1 from the rotational or Z axis **50** which forms one of the three mutually orthogonal axes X, Y and Z in FIGS. **4**A and **4**B. The curved peripheral side surfaces **42** and **44** of the sprag member **30** also contact a pair of mutually diverging side wall surfaces **52** and **54** of a groove **55** formed in the body of the reaction member **34**. The peripheral contact surfaces **42** and **44** contact the side walls **52** and **54** in the diametrically opposing regions **56** and **58** which are also located at the radius R_1 of the drive member **32**.

Further, as shown in FIG. 4B, both pairs of side wall surfaces **38**, **40** and **52**, **54** of the driver member and reaction member, respectively, are of the same type, i.e. flat surfaces which respectively contact curved, i.e. convex peripheral side wall surfaces **42** and **44** of the sprag member **30**. It should be noted that the radius of curvature R_2 of the surfaces **42** and **44** is extremely large relative to R_1. This permits the sprag member **30** to roll in the grooves **36** and **55** of the drive and the reaction members **32** and **34** via pairs of mutually opposing contact surfaces.

What is provided is a three-dimensional (3-D) sprag device but which now involves a second angle ϕ as shown in FIG. 4B. The angle ϕ is the angle between a line between the points of contact **46**, **48** and **56**, **58** and radius of curvature R_2 and defines both the angle of the grooves **36** and **55**, and the angle of the contact surfaces **42** and **44** of the sprag member **30**.

In such a configuration, the reaction force F_R' now includes a term sin ϕ and which can be expressed as F_R and where,

$$F'_R=FR/\sin\phi \tag{10}$$

in which case, equation (9) is now expressed as,

$$(F\sin\theta)(\sin\phi)/F_R(1+\cos\theta)\leqq\mu's \tag{11}$$

where μ's is the coefficient of friction for the 3-D embodiment (FIGS. **4A** and **4B**) and, therefore

$$\mu'_s=\mu_s/\sin\phi. \tag{12}$$

This indicates that the angle θ for a 3-D embodiment can be inherently larger than the angle θ for a 2-D configuration as shown in FIGS. **1A** and **1B**.

This also means that the locking capabilities of a 3-D roller type sprag member such as shown in FIG. **4B** is improved by a factor of 1/sinϕ. For a contact angle of θ=30°, for example, this effectively doubles the locking effectiveness. This locking effectiveness can be utilized in, for example, three different ways. If the angle θ of the incline and the coefficient of static friction (μ's) remain the same, the margin of safety and reliability of locking over slipping increases several times depending upon the sprag-groove contact angle. On the other hand, one can obtain the same margin of safety and reliability and using different materials and more slippery lubricants without penalty. That is, the static coefficient of friction can be reduced or in some ways relaxed. The third way of utilizing and improving locking effectiveness is to increase the angle θ of the incline while keeping the static coefficient of friction μ_S the same. This has the effect of increasing the torque output of a brake/clutch device employing locking sprags without increasing the contact stresses on the sprags.

At the same time, very compact 3-D sprags can withstand very large forces and still maintain modest contact forces. Contact stresses for a point contact between 2 spheres on which one sphere is inside the other are calculated as shown in equation (13) below:

$$P_o=(1/R_1-1/R_2)(E/2)^2p]^{1/3} \tag{13}$$

where:

P_o is the contact stresses,

R_1 is the inside radius (sprag),

R_2 is the outside radius (groove),

E is the materials modulus of elasticity and

P is contact load.

With 3-D sprags, the contact radius R_2 as shown in FIG. **4B** acts against a flat surface, for example **52** and **54**, as shown; however, R_2 is independent of the sprag roll radius R_1 in FIG. 4A. Thus $R_2 >> R_1$ without effecting the size of the sprag **30**. R_2 in FIG. **4B** corresponds to R_1 in the equation (13) and the flat grooves in FIG. **4B** correspond to P_2 in the equation where $R_2 \to \infty$.

Thus with a very large contact radius operating against an opposing e.g. flat surface, very large forces can be withstood with minimal contact stresses. Studies have shown that if one uses,

$$P_o=2[(1/R_1-1/R_2)(E/2)^2P]^{1/3} \tag{14}$$

a conservative approximation is obtained (within 10%) in the 3-D sprag case.

It is clear that P_o can be kept very small despite large P loads and this entirely independent of the sprag roll radius R_1,

Furthermore, a 3-D sprag geometry has significant advantages in the performance of both the inner disk or driver member **32** and the outer ring or reaction member **34** in FIGS. 4A and 4B respectively. The 2-D case of FIG. **1A** and FIG. **1B** shows a convex surface of a 2-D sprag **10** bearing on a convex surface of an inner disk **13**. This arrangement is inherently prone to large stress concentrations and is somewhat analogous to P_o in equation (**13**). Therefore, it is not surprising that, classically, the inner disk/sprag surface is the weak point of sprag clutch/brake devices.

With 3-D sprag techniques, however, this problem is by passed. The dominant effect is a convex sprag surface bearing, for example, against a flat or curved reaction or driver surface, with the radius R_2 of the sprag surface as large as desired, thus keeping the contact stresses low as permitted in the previously shown equation (14).

The 3-D sprag geometry also presents advantages for the outer ring or reaction member. In the 2-D geometry, the reaction member **14** (FIG. **1A**), **14**' (FIG. **2**), and **14**" (FIG. **3**) must be made both long in axial length and thick to guard against bending deformations brought about by the very large bearing forces. Elastic (and plastic) bending deformations are caused, in large part, by the geometric moment of inertia of the cross section of this member. In the case of the 2-D sprag, this is a long, narrow rectangle which has as its rotational center, a line through the center of the rectangle in the axial direction. This geometry is very weak in bending. Increasing the axial length, a linear function does little to help; thickness, a cubic function, is required. In the 3-D sprag case, the flange thicknesses of the reaction member **34** (FIG. **4B**) which comprise the contact surfaces with the sprag member **30** provide this thickness and thus this geometry is very resistant to bending deformations. This results despite it being relatively short in axial length and despite very thin walls in the region between the outer limit of the groove **56** and the outside of the reaction member **34**. Also, 3-D geometry permits thick flanges without requiring a corresponding increase in the overall diameter of the device.

Further, all that is required to convert a 2-D sprag device to a 3-D device is to change from cylindrical contact as shown in FIG. **1B** to a contact between diametrically opposing sides of the grooves and four contact surfaces angled with respect to the axial direction of the sprags as shown in FIG. 4B. Thus the 2-D configurations of FIGS. **2** and **3** can be converted to 3-D configurations as shown in FIGS. **5** and **6** by the inclusion of grooves **36** and **55** in the drive member **32'** and reaction member **34'** of the configuration of FIG. **5** and grooves **36** and **55** in the drive member **32"** and the reaction member **34"** in the configuration shown in FIG. **6**. In both instances, the sprag members **30'** and **30"** now include a pair of spaced peripheral contact surfaces having a radius R_1 as shown in FIG. 4B and consisting of the surfaces **42** and **44**.

It is not essential that a 3-D sprag system be comprised of a combination of flat and rounded contact surfaces as configured in FIG. **4**B, nor is it necessary that the sprag member **30** be a male-type member while the drive members **32** and the reaction member **34** be female type members.

FIGS. **7**A–**7**D, for example, disclose four variations of surface contact configurations of FIG. **4**B for a male sprag and a female type reaction member. In FIG. **7**A, the sprag member $\mathbf{30}_a$ includes a pair of convex contact surfaces **42** and **44** such as shown in FIG. **4**B; however, the reaction member **34***a*, includes a pair of convex contact surfaces **60** and **62** in the groove **55***a* instead of the flat contact surfaces **52** and **54**. As to the arrangement shown in FIG. **7**B, the sprag member $\mathbf{30}_b$ includes a pair of convex contact surfaces **42** and **44** like that shown in FIG. **7**A; however, the reaction member $\mathbf{34}_b$ now includes a pair of concave contact surfaces **64** and **66** in the groove $\mathbf{55}_b$. With respect to the scheme shown in FIG. **7**C, the sprag member $\mathbf{30}_c$ includes a pair of flat contact surfaces **68** and **70**, while the reaction member $\mathbf{34}_c$ includes a pair of convex contact surfaces **60** and **62** such as shown in FIG. **7**A. In FIG. **7**D, the configuration is shown where the sprag member $\mathbf{30}_d$ includes a pair of concave contact surfaces **72** and **74**, while the reaction member $\mathbf{34}_d$ includes a pair of convex contact surfaces **60** and **62** in the groove $\mathbf{55}_d$.

Turning attention now to FIGS. **8**A–**8**D, female type sprag members $\mathbf{30}_e \ldots \mathbf{30}_h$ engage male type reaction members $\mathbf{34}_e \ldots \mathbf{34}_h$. In FIG. **8**A, there is shown a female type sprag member $\mathbf{30}_e$ including a pair of convex surfaces **76** and **78** in a groove **80***e*, while the male type reaction member $\mathbf{34}_e$ includes a pair of convex contact surfaces **82** and **84**. In the embodiment of FIG. **8**B, the reaction member **30***f* also includes a pair of convex contact surfaces **76** and **78**, while the sprag member **34***f* includes a pair of flat contact surfaces **86** and **88**. As to the embodiment of FIG. **8**C, it discloses a reaction member **30***g* having a pair of concave contact surfaces **90** and **92** which abut a pair of convex contact surfaces **82** and **84** on the sprag member **34***g*. When desirable, both sets of contact surfaces **90**, **92** and **82**, **84** may comprise continuous curved surfaces. Finally, with respect to the embodiment shown in FIG. **8**D, it depicts a reaction member $\mathbf{30}_h$ having a pair of convex contact surfaces **76** and **78** in a reaction member groove $\mathbf{80}_h$ and which are adapted to contact a pair of concave contact surfaces **94** and **96** in the sprag member $\mathbf{34}_h$.

It should be noted that it is possible to have any number of variations of the schemes shown in FIGS. 7A–7D and 8A–8D. For example, one can have the top of the sprag as a groove, and the bottom as a male member which will mate with corresponding ridges and grooves in the reaction and drive members, respectively, or vice versa. Also, the contact angles of the top and bottom of the sprags can be different, depending upon the performance desired.

Having thus shown and described what is at present considered to be the preferred embodiments of the invention, it should be noted that the same has been made by way of illustration and not limitation. Accordingly, all alterations, modifications and changes coming within the spirit and scope of the invention are herein meant to be included.

I claim:

1. A torque coupling sprag system, comprising:

a drive member selected from a male type and a female type member, said drive member including a first pair of mutually spaced apart and mutually inclined contact surfaces for directly contacting a sprag member, said sprag member having an outermost perimeter located in a plane normal to an axis of rotation of said sprag member,

a reaction member including a second pair of mutually spaced apart and mutually inclined contact surfaces for directly contacting said sprag member, and

said sprag member selected from a male type and a female type member opposite said selection of said drive member and said reaction member and located between and biased against said pairs of contact surfaces of both said drive member and said reaction member and having a third pair of mutually spaced apart contact surfaces in direct contact with said first pair of contact surfaces of said drive member and a fourth pair of mutually spaced apart contact surfaces in direct contact with said second pair of contact surfaces of said reaction member, at a location radially inside said outermost perimeter of said sprag member, and

wherein one pair of contact surfaces of said first and third pairs of contact surfaces and one pair of contact surfaces of said second and fourth pairs of contact surfaces, respectively, comprise curved contact surfaces having a predetermined radius of curvature, and

wherein said sprag member comprises a rotatable member having a radius of rotation and wherein said radius of curvature of said third and fourth pairs of contact surfaces is relatively large relative to said radius of rotation.

2. A sprag system in accordance with claim **1** wherein said sprag member comprises a member rotatable about said axis of rotation and said reaction member is inclined relative to said drive member and forming an angle therebetween defined by a straight line passing through said axis of rotation and said first and third pairs of contact surfaces and a straight line passing through said axis of rotation and said second and fourth pairs of contact surfaces.

3. A sprag system in accordance with claim **2** wherein said third and fourth pair of contact surfaces of said sprag member have a contact radius of curvature of a first value for contacting said first and second pair of contact surfaces of said drive member and said reaction member, respectively, and said sprag member has a radius of rotation about said axis of rotation of a second value where said third and fourth pairs of contact surfaces make contact with said first and second pairs of contact surfaces, wherein said contact radius of curvature being determined and shaped independently of said radius of rotation and said first value is greater than said second value.

4. A sprag system in accordance with claim **3** wherein $R_2 \gg R_1$, where R_1 is the radius of rotation, and R_2 is the contact radius of curvature.

5. A sprag system in accordance with claim **4** wherein said first and second pairs of contact surfaces are located in grooves in an outer surface of said drive member and said reaction member, respectively, and wherein said third and fourth pairs of contact surfaces are respectively located on peripheral portions of said sprag member.

6. A sprag system in accordance with claim **5** wherein said grooves include pairs of flat surface segments in said drive member and said reaction member, said first and second pairs of contact surfaces respectively located on said flat surface segments, and wherein said peripheral portions of said sprag member include a pair of convex surface segments, said third and fourth pairs of contact surfaces respectively located on said convex surface segments.

7. A sprag system in accordance with claim **5** wherein said grooves include pairs of concave surface segments in said drive member and said reaction member, said first and second pairs of contact surfaces being respectively located on said concave surface segments, and wherein said peripheral portions of said sprag member include a pair of convex surface segments, said third and fourth pairs of contact surfaces being respectively located on said convex surface segments.

8. A sprag system in accordance with claim **5** wherein said grooves include pairs of convex surface segments in said drive member and said reaction member, said first and second pairs of contact surfaces respectively located on said convex surface segments, and wherein said peripheral portions of said sprag member include a pair of flat surface segments, said third and fourth pairs of contact surfaces respectively located on said flat surface segments.

9. A sprag system in accordance with claim **5** wherein said grooves include pairs of convex surface segments, in said drive member and said reaction member, said first and second pairs of contact surfaces respectively located on said convex surface segments, and wherein said tapered peripheral portions include a pair of concave surface segments, said third and fourth pairs of contact surfaces respectively located on said concave surface segments.

10. A sprag system in accordance with claim **4** wherein said first and second pairs of contact surfaces are located in peripheral outer surface portions of said drive member and said reaction member, respectively, and wherein said third and fourth pairs of contact surfaces are located in a groove in an outer surface of said sprag member.

11. A sprag system in accordance with claim **10** wherein said peripheral outer surface portions of said drive member and said reaction member respectively include a pair of convex surface segments, said first and second pairs of contact surfaces respectively located on said convex surface segments, and wherein said groove in said sprag member include a pair of convex surface segments and said third and fourth pairs of contact surfaces are respectively located on said pair of convex surface segments.

12. A sprag system in accordance with claim **10** wherein said peripheral outer surface portions of said drive member and said reaction member respectively include a pair of flat surface segments, said first and second pairs of contact surfaces respectively located on said flat surface segments, and wherein said groove in said sprag member includes a pair of convex surface segments and said third and fourth pairs of contact surfaces are respectively located on said pair of convex surface segments.

13. A sprag system in accordance with claim **10** wherein said peripheral outer surface portions of said drive member and said reaction member respectively include a pair of convex surface segments, said first and second pairs of contact surfaces respectively located on said convex surface segments, and wherein said groove in said sprag member includes a pair of concave surface segments and said third and fourth pairs of contact surfaces are respectively located on said pair of concave surface segments.

14. A sprag system in accordance with claim **10** wherein said peripheral outer surface portions of said drive member and said reaction member respectively include a pair of concave surface segments, said first and second pairs of contact surfaces respectively located on said concave surface segments, and wherein said groove in said sprag member includes a pair of convex surface segments and said third and fourth pairs of contact surfaces are respectively located on said pair of convex surface segments.

15. A sprag system in accordance with claim **4** wherein said sprag member comprises a roller member,

16. A sprag system in accordance with claim **4** wherein at least one pair of said pairs of contact surfaces include flat surface segments and wherein an adjoining pair of contact surfaces include curved surface segments.

17. A sprag system in accordance with claim **4** wherein at least one pair of said first and second pairs of contact surfaces are located in grooves in an outer surface of said drive member and said reaction member respectively and wherein said third and fourth pairs of contact surfaces are respectively located on a tapered peripheral portion of said sprag member.

18. A sprag system in accordance with claim **3** wherein at least one of said first and second pairs of contact surfaces comprise a pair of diametrically opposing contact surfaces.

19. A sprag system in accordance with claim **3** wherein at least one of said third and fourth pairs of contact surfaces comprise a pair of diametrically opposing contact surfaces.

20. A sprag system in accordance with claim **1** wherein said drive and reaction members comprise female members and said sprag member comprises a male member.

21. A sprag system in accordance with claim **1** wherein said drive and reaction members comprise male members and said sprag members comprise a female member.

22. A torque coupling sprag system, comprising:

a drive member including a sprag contact surface having a first pair of mutually spaced apart contact surface regions,

a reaction member including a sprag contact surface having a second pair of mutually spaced apart contact surface regions, and

a sprag member located between and biased against said drive member and said reaction member, said sprag member having an outermost perimeter located in a plane normal to an axis of rotation of said sprag member and having a third pair of mutually spaced apart contact surface regions complementary with and in direct contact with said first pair of contact surface regions of said drive member at a location radially inside said outermost perimeter of said sprag member, and having a fourth pair of mutually spaced apart contact surface regions complementary with and in direct contact with said second pair of contact surface regions of said reaction member, and

wherein one pair of contact surfaces of said first and third pairs of contact surfaces and one pair of contact surfaces of said second and fourth pairs of contact surfaces, respectively, comprise curved contact surfaces having a predetermined radius of curvature, and

wherein said sprag member comprises a rotatable member having a radius of rotation and wherein said radius of curvature of said third and fourth pairs of contact surfaces is relatively large relative to said radius of rotation.

23. A sprag system in accordance with claim **22** wherein said first and second pairs of contact surface regions are respectively located in at least one recess formed in said drive member and said reaction member, and wherein said third and fourth pairs of contact surface regions are respectively located on a tapered peripheral outer portion of said sprag member.

24. A sprag system in accordance with claim **22** wherein said first and second pairs of contact surface regions are respectively located on tapered peripheral outer portions of said drive member and said reaction member, and wherein said third and fourth pairs of contact surface regions are respectively located in at least one recess formed in an outer peripheral surface of said sprag member.

25. A sprag system in accordance with claim **22** wherein at least one pair of said first and second pairs of contact surface regions is located in a recess selectively formed in said drive member or said reaction member, and wherein at least one pair of said third and fourth pairs of contact surface regions is selectively located on a tapered peripheral outer portion of said sprag member.

26. A sprag system in accordance with claim **22** wherein at least one pair of said first and second pairs of contact surface regions is located on a tapered peripheral outer portion of said drive member or said reaction member, and wherein at least one pair of said third and fourth pairs of contact surface regions is located in a recess selectively formed in said sprag member.

27. A torque coupling sprag system in accordance with claim **22** wherein said sprag member comprises a member rotatable about said axis of rotation and said reaction member is inclined relative to said drive member and forming an angle therebetween defined by a straight line passing through said axis of rotation and said first and third pairs of contact surfaces and a straight line passing through said axis of rotation and said second and fourth pairs of contact surfaces.

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